

Patellofemoral Arthroplasty

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Background: Patellofemoral arthritis is a common cause of anterior knee pain and limits flexion-related activities of daily living and exercise. While frequently present in bicompartamental and tricompartmental osteoarthritis, patellofemoral arthritis can occur in isolation. Patellofemoral arthroplasty as a treatment option is gaining in popularity, especially with new implant designs. We report a case in which new inlay implants were used to resurface the patellofemoral joint in a patient with contralateral compromise secondary to a previous below-knee amputation.

Case Report: A 37-year-old female with a contralateral right below-knee amputation and progressive left patellofemoral arthritis had failed multiple conservative treatment modalities. She underwent isolated patellofemoral arthroplasty using an inlay-designed implant. The patient was followed for 2 years postoperatively. She noticed an immediate increase in her knee range of motion and her pain scores improved. Two years postoperatively, she demonstrated drastic improvement in all outcome measures: International Knee Documentation Committee score (16.1 to 88.5), Lysholm Knee Scoring Scale (22 to 100), Knee Injury and Osteoarthritis Outcome Score (KOOS) Symptoms (7.14 to 96.43), KOOS Pain (2.78 to 100), KOOS Activities of Daily Living (0 to 100), KOOS Sports (0 to 100), and KOOS Quality of Life (12.5 to 93.75).

Conclusion: Inlay patellofemoral arthroplasty is a valid treatment option for isolated patellofemoral arthritis. Successful results can be achieved with this procedure after failure of conservative measures in patients with limited or no evidence of tibiofemoral arthritis.

Keywords: Amputation, arthritis, arthroplasty–replacement–knee, patellofemoral joint

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INTRODUCTION

Patellofemoral arthritis is a common cause of anterior knee pain. Anterior knee pain is a frequent chief complaint in orthopedic patients. In a study of 204 knees, Davies et al found that patellofemoral joint space narrowing occurred in 33.7% of men and 36.1% of women >60 years of age. This area was involved in isolation in 15.4% of men and 13.6% of women in the same study.¹ In a retrospective review of 31,516 knee arthroscopies evaluating for cartilage lesions, grade III lesions of the patella were prevalent in 20% of patients.² Many conservative and surgical treatment options are available for patients with isolated patellofemoral arthritis. Initial conservative management is preferred and typically involves activity modification with isometric quadriceps strengthening, while limiting open-chain exercises at the patellofemoral joint. Nonsteroidal antiinflammatory medications and steroid injections can be beneficial as well.³ Since the early 2000s, biologic injections have also been used during conservative management and include platelet-rich plasma (typically leukocyte poor), viscosupplementation (a hyaluronic acid preparation of variable molecular

weights), stem cells (various sources), or placental growth factors.^{4–9} All of these options have demonstrated mixed results.

If adequate symptomatic relief is not achieved with these measures, surgical options are considered. Arthroscopic chondroplasty can theoretically help remove inflammatory mediators, mechanical cartilage fragments, and loose bodies, and some studies have shown short-term relief for a 2-year period.^{10–12} Other studies evaluating arthroscopic treatment have demonstrated questionable results.^{13,14} Advancements in cartilage restoration and arthroplasty techniques have led to improved outcomes following more invasive surgical interventions.¹⁵

The optimal intervention is ultimately determined by patient-specific factors. The presence of patellofemoral malalignment as assessed by the tibial tubercle-trochlear groove (TT-TG) distance is important. Articular cartilage lesion size, location, depth, and the involvement of the adjacent surface—the *kissing lesion*—must be considered. Patient comorbidities, particularly body mass index, should help guide the clinician's decision tree as well. Social factors

such as the patient's occupation, desired postoperative activity level, and ability to comply with rehabilitation protocols are equally important.

Surgical Options for Lesions <2 cm²

Microfracture has traditionally been an option for small trochlear lesions <2 cm² in size; however, because of the lack of high-quality evidence and variable outcomes in the patellofemoral joint, this procedure should be used cautiously.¹⁶

An option for patellar maltracking involving bony realignment is tibial tubercle anteromedialization as described by Fulkerson.¹⁷ This procedure has been shown to achieve symptomatic relief by diminishing the load transmitted over an arthritic patellofemoral joint. Successful outcomes have been reported in patients with grade IV lateral facet arthritis and a TT-TG distance >20 mm.¹⁸ Poorer outcomes with the Fulkerson osteotomy have been seen in patients with crush or dashboard-type injuries; consequently, the procedure is not recommended for these patients.¹⁹

Surgical Options for Lesions 2-4 cm²

Autologous chondrocyte implantation (ACI) is a surgical option used with full-thickness cartilage defects >3-4 cm² in the femoral condyles or trochlear groove. This 2-step procedure involves harvesting 200-300 mg of articular cartilage and associated subchondral bone. The tissue is subsequently used to culture and proliferate chondrocytes. At the second stage, cells are implanted with a collagen patch, allowing the cells to adhere to and grow on the subchondral bone surface. ACI has shown good to excellent results in several studies with extended follow-up.²⁰⁻²² In the largest of these studies, Gomoll et al prospectively followed 110 patients who underwent ACI in the patella for a minimum of 4 years; 92% of the patients stated they would undergo ACI again.²² However, the average age of the patients in the Gomoll et al study was 30-35 years.

A modification of ACI is matrix-induced autologous chondrocyte implantation (MACI) in which cells are seeded on a type I/III porcine collagen membrane that is implanted, allowing cells to adhere to the subchondral bone plate.²³ In a 2015 study of MACI outcomes, Ebert et al found 85% satisfaction at 24 months.²⁴ This same group demonstrated that similar results could be obtained with the MACI procedure in the patellofemoral and tibiofemoral joints if concomitant patellar realignment surgery was performed to correct underlying malalignment.²⁴

Osteochondral autograft and allograft transplantations are also options. Osteochondral autograft transplantation can be used to treat 2- to 4-cm² defects. In a direct comparison between the ACI procedure and a mosaicplasty osteochondral autograft transplantation technique (4- to 6-mm diameter plugs), Bentley et al reported no good or excellent results in patients treated with the mosaicplasty technique for patellar defects.²⁵ Although this procedure is an option, results are suboptimal. Osteochondral allograft transplantation for patellofemoral lesions limits donor site morbidity but can have issues with articular cartilage viability and bone incorporation. The current literature supports a limited role for the use of osteochondral allografts in patients with extensive patellofemoral arthritis. Graft survivorship and incorporation are concerns in chronic conditions in which large kissing le-

sions are noted preoperatively or intraoperatively. A study that followed patients undergoing allograft transplantation found <60% graft survival at 10 years.²⁶ Despite these outcomes, osteochondral allograft transplantations have a niche, particularly in young patients. Young individuals with diffuse defects who have failed conservative management and less invasive surgical treatments can have good results with a biojoint procedure replacing both of the patellofemoral surfaces.²⁷

Surgical Options for End-Stage Lesions

For end-stage patellofemoral arthritis, joint arthroplasty can be an excellent option. Debate and controversy center on the most appropriate joint replacement option for these patients. Choices include isolated patellofemoral arthroplasty (PFA), bicompartamental knee arthroplasty (BKA), and total knee arthroplasty (TKA). PFA is indicated for isolated patellofemoral arthritis when chondral and meniscal damage in the medial and lateral compartments is limited and ligamentous stability is appropriate.²⁸ The presence of extensive tibiofemoral joint disease with or without varus/valgus malalignment is a contraindication to PFA. The surgeon should use clinical evaluation, radiographic studies, and magnetic resonance imaging in the patient selection process.²⁹

Arthroscopic confirmation should be performed at the time of surgical intervention to verify clinical suspicions and exclude patients with potential early and intermediate-term failure rates with PFA.³⁰ Isolated PFA, BKA, and TKA have shown similar outcomes for pain relief; however, improved function, earlier return to activities, less intraoperative blood loss, and less surgical time have been seen with PFA and BKA compared to TKA procedures. Dahm et al used the Kellgren-Lawrence radiographic assessment of the tibiofemoral joint and Iwano scoring assessment of the patellofemoral joint to compare the use of PFA and TKA in patients with isolated patellofemoral disease.³¹ At a mean follow-up of 27-29 months, the mean postoperative Knee Society Clinical Rating System scores were 89 following PFA and 90 following TKA. Knee Society Clinical Rating System scores range from 0 to 100, with higher scores indicating better knee conditions. Similarly, mean University of California-Los Angeles (UCLA) activity scores were better in the PFA cohort (6.6) than in the TKA cohort (4.2) ($P < 0.0001$), demonstrating that patients who underwent PFA were able to regularly participate in moderate activities such as bicycling, whereas the TKA patients could not do so regularly. Blood loss ($P = 0.03$) and hospital stay ($P = 0.001$) were lower in the PFA population compared with the TKA population. Blood loss, hospital stay, and functional outcomes were not impacted by age as an independent variable when assessed by linear regression analysis. An additional benefit is the maintenance of normal knee kinematics with PFA and BKA compared to TKA as a result of retention of the anterior/posterior cruciate ligament central pivot, proprioception, and bone structure maintaining the radius of curvature of the femoral condyles.³²⁻³⁵

Despite these benefits, progression of osteoarthritis in the remaining compartments is a possibility; therefore, the patient should be warned of the potential need for a future TKA. One retrospective study demonstrated a 21% conversion rate of PFA to TKA at an average of 5.5 years.³⁶ Revision from PFA to a TKA at a later date has been performed without complication, making PFA an attractive alternative for young

patients who would likely outlive the lifetime of their total knee implant.³⁷

We present a unique case of a patient who underwent a PFA in the setting of a contralateral BKA.

CASE REPORT

A 37-year-old female who had been involved in a motor vehicle collision 13 years prior that led to a right below-knee amputation presented with complaints of significant left anterior knee pain. Her pain had progressed to the point that she was having frequent episodes of nocturnal pain that aroused her from sleep. Her below-knee amputation in the opposite knee placed increased stress on the patellofemoral joint in the involved knee during activities of daily living. She had undergone extensive conservative treatment modalities, including activity modification, physical therapy, and oral nonsteroidal antiinflammatory medications. She received intraarticular corticosteroid injections that provided brief symptomatic relief. Despite these interventions, she continued to have severe and debilitating pain.

On physical examination, her range of motion in the left knee was 0-100 degrees with audible and palpable crepitus at the patellofemoral joint. The patellofemoral grind test replicated her pain. The patient had no patellar malalignment, a negative J sign, and no patella alta. She had no evidence of patellar instability, with patellar glide 1 quadrant laterally and 2 quadrants medially at 30 degrees flexion. The patient demonstrated no apprehension on provocative testing at 30-45 degrees flexion. Radiographs revealed minimal changes in the medial and lateral compartments with preservation of the joint space radiographically on anterior-posterior and lateral standing views (Figures 1A and 1B, respectively) but severe degenerative changes in the left patellofemoral joint with sclerosis and hypertrophic bone formation on Merchant view (Figure 1C). Magnetic resonance imaging demonstrat-

ed intact meniscal and ligamentous structures. These images showed intact articular cartilage surfaces in the medial and lateral compartments. Given the patient's young age, lack of medical comorbidities, preserved medial and lateral compartments, and failure of extensive conservative treatment, the decision was to proceed with PFA. Prior to intervention, several baseline outcome scores were obtained: International Knee Documentation Committee (IKDC) score, the Lysholm Knee Scoring Scale, and Knee Injury and Osteoarthritis Outcome Score (KOOS) components (Symptoms, Pain, Activities of Daily Living, Sports, and Quality of Life). For all 3 scales, higher scores indicate better function.

Surgical Procedure

Arthroscopy was first performed using standard anterolateral and anteromedial portals. An International Cartilage Repair Society (ICRS) grade IV 4 × 3-cm lesion was noted along the entire trochlear area; an additional 3 × 3-cm ICRS grade IV kissing lesion was noted in the central eminence of the patella (Figures 2A and 2B). The patella demonstrated significant lateral tilt and diffuse synovitic changes. Scarring in the intercondylar notch was evident and subsequently debrided.

Cruciate ligament (Figure 3A), menisci (Figures 3B and 3C), and remaining articular cartilage structures were visualized arthroscopically and demonstrated no significant pathology. A 1-cm² ICRS grade II cartilage lesion of the medial femoral condyle was treated with gentle arthroscopic debridement to stable borders.

The medial portal was closed and a lateral incision was made, incorporating the anterolateral portal. A lateral subvastus approach was utilized through a miniarthrotomy (4 cm). Bone spurs were removed as encountered. The trochlear lesion was exposed. The Arthrosurface joint replacement system (Arthrosurface) provides several sizing guides that

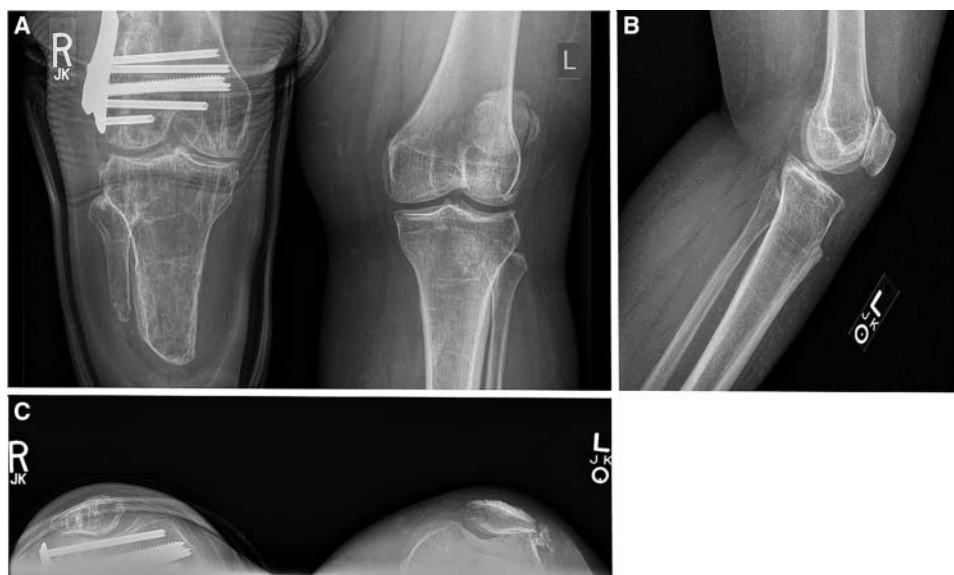


Figure 1. Preoperative radiographs from (A) anterior-posterior, (B) lateral, and (C) Merchant views demonstrate severe left patellofemoral arthritis with preserved tibiofemoral joint spaces and a right below-knee amputation stump with open reduction internal fixation hardware in place.

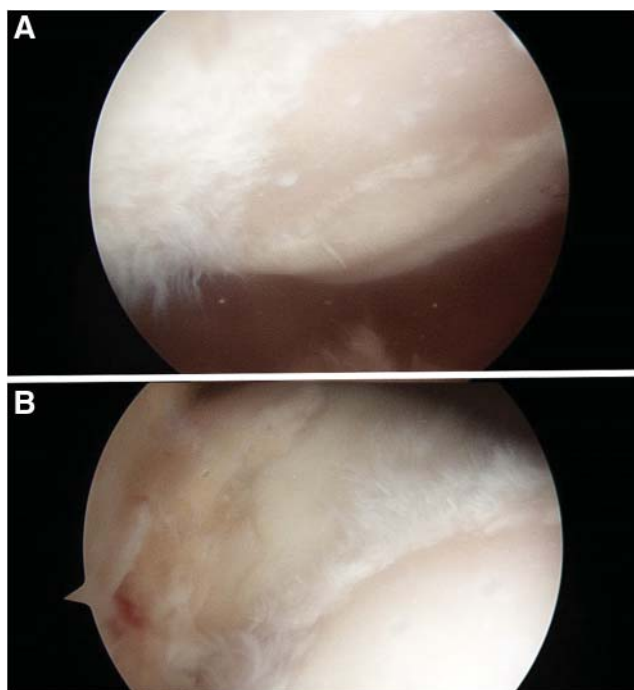


Figure 2. Intraoperative arthroscopic images demonstrate severe osteoarthritis with complete cartilage loss on the undersurface of the (A) patella and (B) the trochlea.

assess the patient's trochlear groove bone geometry in the sagittal and coronal planes. Measurements revealed that an 8.5 × 4-mm femoral implant was most appropriate for our patient. The femoral lesion was reamed centrally, proximally, and distally using the Arthrosurface guides and reamers. Further contouring of the proximal-distal and medial-lateral lesion edges with a high-speed burr was performed to prevent prominence of the trochlear implant on flexion and extension at 30-60 degrees postoperatively. The central hole was tapped to appropriate depth using the Arthrosurface guide to limit bone penetration. In the Arthrosurface system, the central screw maintains the appropriate depth of the implant, avoiding subsidence (Figure 4A). The trochlear implant was impacted into the screw using a modular technique (Figure 4B). Bleeding bone was maintained along the surface, and a press-fit HemiCAP (Arthrosurface) trochlear implant was placed in anatomic position.

Attention then turned to the patellar lesion. The center of the lesion was visualized (Figure 4C), and the central pin was applied using the Arthrosurface 9-mm dome patella trial as a guide. Care was taken to maintain bone geometry while maximizing coverage of the patellar lesion. With the pin in position, an Arthrosurface reamer was used to remove the damaged articular surface to the appropriate depth. The 9-mm dome patella trial was applied. The inlay patella implant requires further contouring of the peripheral edges of the remaining bone structure to prevent impingement on the trochlear implant with flexion and extension. Contouring of the patella periphery was performed with a rongeur. The knee was ranged, and adequate patellofemoral tracking was noted; in particular, smooth central tracking with no mechanical palpable or audible irregularities was demonstrat-

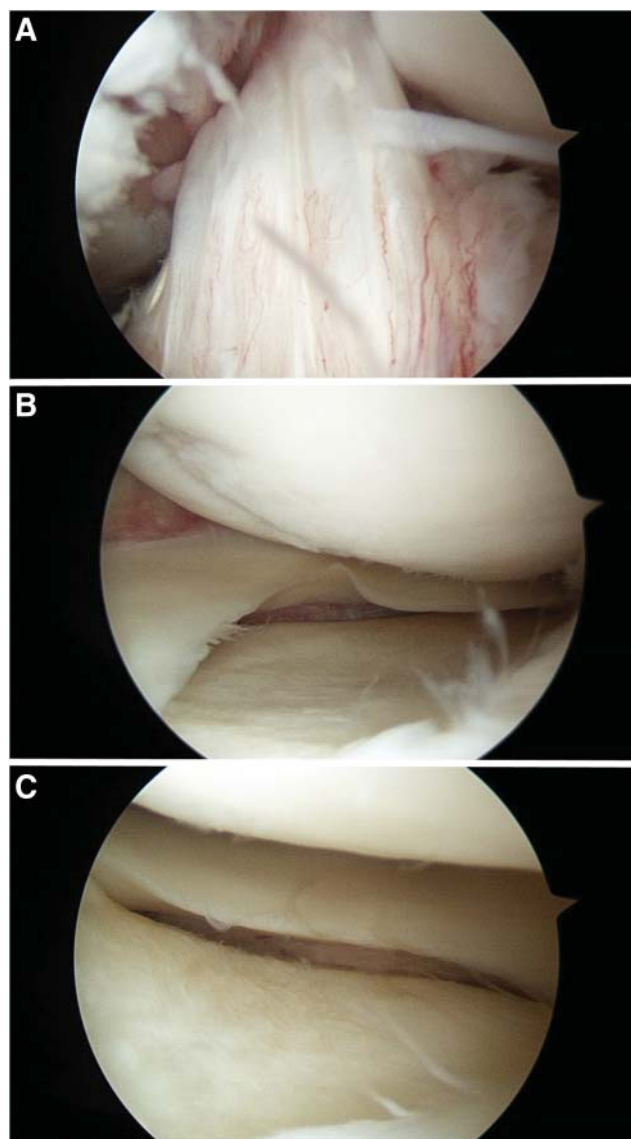


Figure 3. Intraoperative images of the (A) anterior cruciate ligament, (B) medial meniscus, and (C) lateral meniscus demonstrate no concomitant pathology.

ed on passive flexion and extension from 0-130 degrees. The 9-mm dome patella polyethylene implant was cemented into position (Figure 4D). A final assessment after cement hardening demonstrated excellent patellar tracking (Figure 4E). The wound was irrigated, and deep/superficial lateral knee layer closure was performed in standard fashion.

Postoperative Care and Follow-Up

Postoperatively, the patient was immediately placed in a continuous passive motion machine from -10 to 120 degrees flexion for 6-8 hours per day for 4 weeks. Immediate full weight-bearing as tolerated was allowed with walker assistance. The patient began physical therapy 1 week after surgery. On her first postoperative visit at 2 weeks, she had 0-110 degrees of motion and was progressed to crutches. On her second postoperative visit at 6 weeks, her flexion had improved to 115 degrees. At 8 months

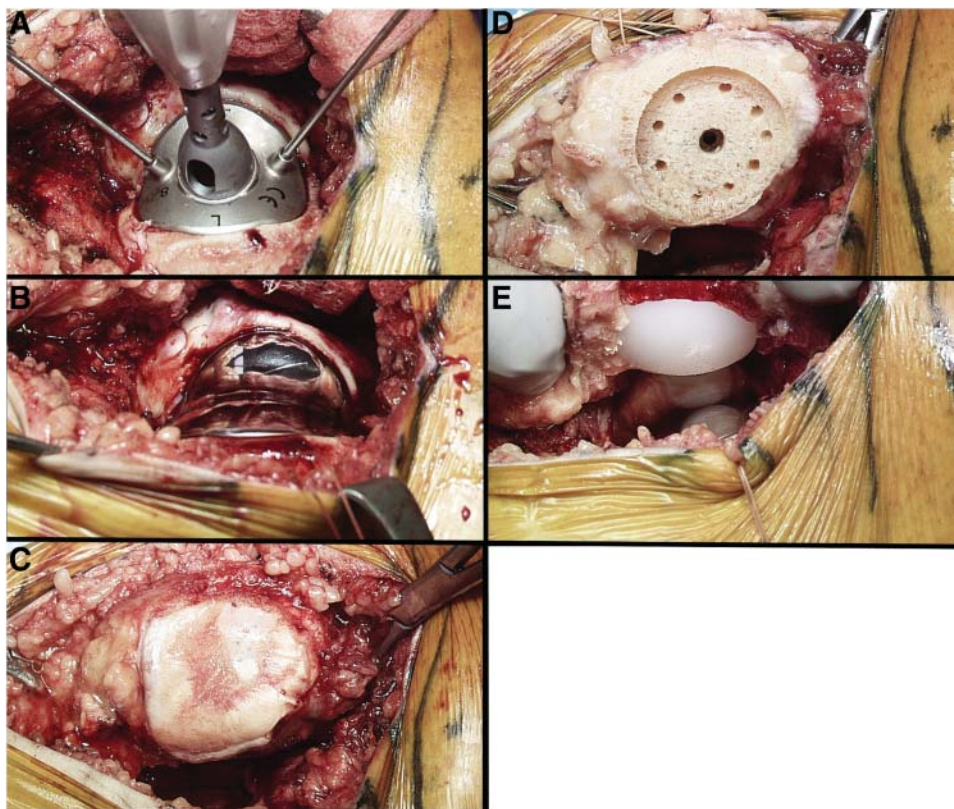


Figure 4. Intraoperative images show (A) preparation of the trochlea, (B) final trochlear groove implant with inlay implant lying flush with the native femoral cartilage, (C) undersurface of the patella with severe arthritis changes and complete loss of cartilage, (D) undersurface of the patella after preparation with all of the arthritic cartilage removed, and (E) final patella implant.

postoperatively, she demonstrated knee flexion to 130 degrees and showed improvement in all outcome measures. Two years postoperatively, she was contacted via telephone to complete outcome scoring. She continued to show great improvement in all outcome measures. The Table shows the

patient's baseline, 8-month, and 2-year outcomes scores. She was pain free 2 years postoperatively (KOOS Pain 100). Radiographs taken 2 years postoperatively (Figure 5) demonstrate well-positioned components without evidence of loosening and appropriate tracking of the patella.

Table. Patient Outcome Scores at Baseline and Follow-Up

Outcome Measure	Preoperative Scores	8-Month Postoperative Scores	2-Year Postoperative Scores
International Knee Documentation Committee score ^a	16.1	71.26	88.5
Lysholm Knee Scoring Scale ^b	22	74	100
Knee Injury and Osteoarthritis Outcome Score (KOOS) ^c			
KOOS Symptoms	7.14	75	96.43
KOOS Pain	2.78	88.89	100
KOOS Activities of Daily Living	0	86.76	100
KOOS Sports	0	80	100
KOOS Quality of Life	12.5	68.75	93.75

^aThe International Knee Documentation Committee score (0-100) provides an overall knee function score. A higher score indicates better function.

^bThe Lysholm Knee Scoring Scale is a scoring system (0-100) for anterior cruciate ligament and chondral defects. A higher score indicates better outcome with fewer symptoms or disability.

^cThe Knee Injury and Osteoarthritis Outcome Score (KOOS) has 5 separately scored subscales. Each question is assigned a score (0-4), and a normalized score is calculated for each subscale (100 indicates no symptoms and 0 indicates extreme symptoms).

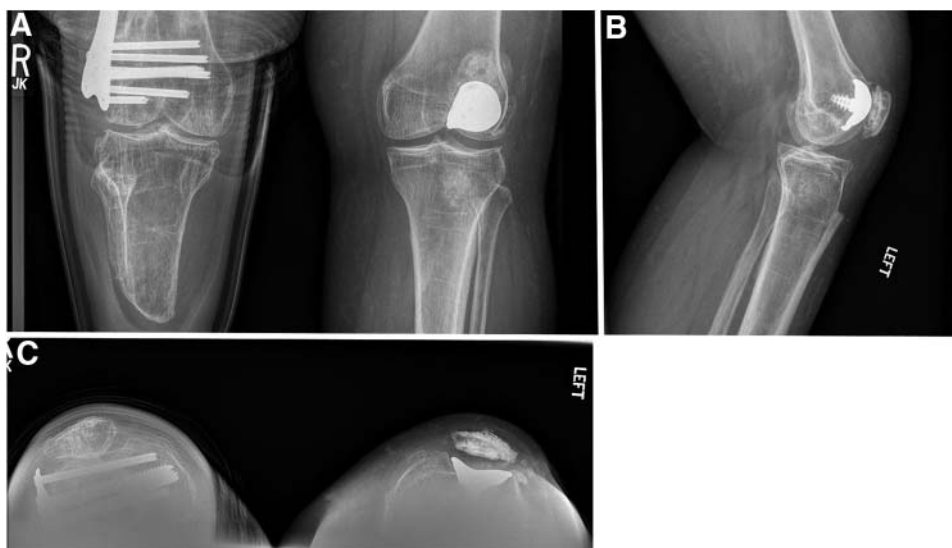


Figure 5. Two years postoperatively, radiographs from (A) anterior-posterior, (B) lateral, and (C) Merchant views demonstrate patellofemoral arthroplasty implants in good position with excellent patellofemoral tracking.

DISCUSSION

Based on the change in her outcome scores, our patient had a dramatic improvement in quality of life after her PFA. PFA declined in popularity in the 1980s and 1990s, but the technique has seen a resurgence for treatment of isolated patellofemoral arthritis refractory to conservative modalities.³⁸ PFA dates to 1955 with the report by McKeever of patellar resurfacing for patellofemoral arthritis.³⁹⁻⁴¹ When continued follow-up at 22 years after implantation showed satisfactory results in 39 of 45 patients with McKeever prostheses, the efficacy of PFA gained increased traction.⁴¹ Advances in PFA technique and the development of new inlay hardware components have made this procedure a useful alternative to TKA in select patients. Given the select role of PFA in the patellofemoral arthritis treatment algorithm, it is important to reiterate its specific indications: failure of conservative treatment measures, absence of or corrected malalignment, intact medial and lateral menisci, and intact cruciate and collateral ligaments.⁴²

Compared to TKA, PFA is an excellent option for young patients as it extends function, reduces pain, and preserves significant native bone stock.^{28,43} If tibiofemoral arthritis subsequently develops, the conversion to TKA can be accomplished with removal of the PFA hardware without compromising the integrity of the remaining bone.⁴² In a study assessing functional scores at 24-month follow-up, Imhoff et al found that 81% of patients were either satisfied or very satisfied with their outcomes.⁴⁴ In a direct comparison of TKA to PFA for treatment of isolated patellofemoral arthritis, PFA had equivocal clinical outcomes while decreasing both intraoperative blood loss and hospital length of stay.³¹

The original onlay PFA implant designs did not place the trochlear implant flush with the femoral surface. This design may have led to the initially higher rates of reoperation for instability, patellar maltracking, and progression of tibiofemoral arthritis.⁴⁵ Second-generation inlay designs lie flush

with the surrounding cartilage and allow for individualized anatomic trochlear resurfacing, offering several advantages described by Lonner in 2007.⁴⁶ The new design increases implant stability, leads to less overstuffing of the patellofemoral joint, and has less patellofemoral mechanical complications, but these design improvements have not been clearly reflected in the current literature.⁴⁷ However, patients with the second-generation inlay designs have been found to be less likely to have progression of tibiofemoral arthritis at 26 months, suggesting that this design can lead to superior long-term outcomes.⁴⁷

CONCLUSION

Anterior knee pain because of patellofemoral arthritis is a common cause of patient visits to orthopedic surgeons. After failure of conservative measures, several operative techniques provide options for managing patellofemoral arthritis. The current literature demonstrates that PFA using second-generation inlay designs is a safe and effective option. This procedure offers several benefits compared to TKA and onlay-designed PFA. Despite the superiority of PFA, the long-term follow-up literature for this design can lead to limited, and thus further studies are warranted to fully explore its benefits and efficacy.

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